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BULLETIN No. 20—PART V.

LODE-GOLD DEPOSITS

VANCOUVER ISLAND

by

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PREFACE.

Bulletin 20, designed for the use of those interested in the discovery of gold-bearing lode deposits, is being published as a series of separate parts. Part I. is to contain information about lode-gold production in British Columbia as a whole, and will be accompanied by a map on which the generalized geology of the Province is represented. The approximate total production of each lode-gold mining centre, exclusive of by-product gold, is also indicated on the map. Each of the other parts deals with a major subdivision of the Province, giving information about the geology, gold-bearing lode deposits, and lode-gold production of areas within the particular subdivision. In all, seven parts are proposed:—

PART I.—General *re* Lode-gold Production in British Columbia.
PART II.—South-eastern British Columbia.
PART III.—Central Southern British Columbia.
PART IV.—South-western British Columbia, exclusive of Vancouver Island.
PART V.—Vancouver Island.
PART VI.—North-eastern British Columbia, including the Cariboo and Hobson Creek Areas.
PART VII.—North-western British Columbia.

By kind permission of Professor H. C. Gunning, Department of Geology, University of British Columbia, his compilation of the geology of British Columbia has been followed in the generalized geology represented on the map accompanying Part I. Professor Gunning's map was published in "The Miner," Vancouver, B.C., June–July, 1943, and in "The Northern Miner," Toronto, Ont., December 16th, 1943.

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LODE-GOLD DEPOSITS, VANCOUVER ISLAND.

BY

J. S. STEVENSON.

CHAPTER I.

INTRODUCTION.

Prospecting on Vancouver Island may be more intelligently undertaken and a greater measure of success assured if the prospector, scout, or engineer has some knowledge of the mining history, general geology, and features of the known gold properties, both producers and non-producers, on the island. The writer will therefore discuss at some length the general geology and features of the known gold prospects and, based on this discussion, will suggest areas for further prospecting.

Although the geology is discussed in detail, only those features that are readily distinguishable in the field and are likely to be of use in determining favourable and unfavourable rocks or rock associations will be described. By going thus into the geology the writer hopes to answer some of the questions of interpretation that may confront the prospector in the field.

MAPS.

The following maps, at various scales, showing the geography of Vancouver Island, may be obtained from the Chief Geographer, Department of Lands, Victoria, B.C.:—

Map No.	Year of Issue.	Title of Map.	Scale.	Per Copy.
		LAND SERIES.		
2A	1938	Southerly Vancouver Island	4 miles to 1 in.	$0.50
2C	1929	Northerly Vancouver Island	4 miles to 1 in.	.50
		MISCELLANEOUS.		
PWD	1939	Highway and Travel Map of British Columbia	20 miles to 1 in.	.25
MD	1939	British Columbia Mining Divisions and Mineral Survey Districts (shows locations of Mining Recorders' offices)	50 miles to 1 in.	Free
———	———	Departmental Reference Maps (a series of sheets which cover the whole Province), "Blue" or "Ozalid" Prints	2 miles to 1 in., 1 mile to 1 in., and ½ mile to 1 in.	$1.00 per sheet
———	———	Departmental Mineral Reference Maps (covering the principal mining areas of the Province), "Blue" or "Ozalid" Prints	1,500 ft. to 1 in.	$1.00 per sheet

GENERAL TOPOGRAPHY AND MEANS OF ACCESS.

The island is, in general, mountainous. A backbone of high mountains with much permanent snow extends from Quatsino Sound south-easterly to Alberni Canal. North-westerly from the sound and south-easterly from the canal, the hills are lower and towards both ends of the island become gently rolling. Along the eastern side the island is plain-like for distances of from 1 to 10 miles back from the coast. Because climate and topography there are more favourable, the eastern side and southern end of the island are more thickly populated and better served by roads than the western coast and northern end.

The western side of the island is rugged and has a typical fjord coast-line. Two limited parts of this coast are served by roads, one from Victoria to Jordan River and one from Nanaimo to Port Alberni on Alberni Canal, and the several ports are served by Canadian Pacific Steamship service on a tri-monthly schedule from Victoria and Port Alberni. Several points on the western coast are served also by airplane from Vancouver. Because of the rugged fjord-like nature of that coast-line no trunk roads have been built along it. Short isolated sections of road have been built from Ucluelet to Tofino, up the Bedwell and the Zeballos Rivers, and from Port Hardy to Quatsino Sound.

CLIMATE.

The climate of the island in general is mild. The annual precipitation ranges from about 30 inches on the eastern coast to more than 110 inches on the western coast. The snowfall is light on the southern and eastern coast and on the immediate western coast, but becomes more abundant as the mountains, a few miles inland from the western coast, are approached.

HISTORY OF MINING.

Although lode gold had been discovered in 1851 on the Queen Charlotte Islands and small amounts were found around Nanaimo, it was not until the '60's that commercial quantities of gold, as placer, were recovered on Vancouver Island. In the '60's the placer deposits on the Leech, Jordan, and Bedwell Rivers, and China Creek, were worked. Copper showings were found and worked as early as 1874 on the Sooke peninsula, and silver ores carrying some gold had been produced as early as 1880 from the *Sterling* claim on the Koksilah River, but it was not until 1892 that gold-quartz veins were found on the island. The first discovery was on China Creek, followed in 1898 by discoveries on Kennedy (Elk) River and on the Bedwell River.

Activity in prospecting for gold and gold-mining in the western part of the island had subsided by 1900 and little was done until 1933 and 1934 when the first discoveries were made and ore was shipped from rich gold-quartz veins in the Zeballos River area on the west coast. At practically the same time finds were made at Herbert Arm and up Bedwell River. Since 1934 the western coast, represented chiefly by the mines in the Zeballos area, has produced nearly 270,000 oz. of gold. In the period from 1898 to 1909, and again in 1943, copper and later copper-zinc mining at Mount Sicker, near Duncan, yielded gold as an important by-product. The total gold recovery from this camp has exceeded 36,000 oz.

CHAPTER II. GEOLOGY.

INTRODUCTORY STATEMENT.

The discussion of the geology which follows represents an abstract of information contained in several Geological Survey of Canada reports by Gunning and Bancroft and in Department of Mines of British Columbia reports by Sargent on areas in the northern part of the island, and of information in Geological Survey of Canada reports by Clapp and Cooke on the southern part of the island. These reports and others are listed in the bibliography on pages 13 and 14 and in lists of references found after the description of mineralized areas. Acknowledgment is made of these sources of information. The present writer accepts responsibility for many of the generalizations made, particularly on the geology in areas not covered by geological maps.

The general geology of Vancouver Island and adjacent coast, as known in 1928, is shown on the Vancouver Sheet, Map 196A, published by the Geological Survey of Canada on a scale of 8 miles to the inch.

For convenience in discussing the general geology, the island will be divided into two parts, Northern and Southern Vancouver Island. These parts are separated by a

line which, from Cape Beale at the southern side of the entrance of Barkley Sound, follows the south-eastern side of the sound, thence runs northerly up Alberni Canal and to a point a few miles past the northern end of the canal, from which point the line runs due east to the eastern coast of the island.

This subdivision of the island does not extend into the more particular discussion of areas and mineral deposits.

In the southern part of the island a few formations have been mapped, which have not been recognized in the northern part, largely because the southern part has been more thoroughly mapped and therefore greater opportunity has been afforded to distinguish between and correlate a greater number of rock-types.

Most of the gold properties have been found in the northern part of the island. In the southern part, from the 49th parallel southward and from the Nitinat River eastward, about twenty-five copper, four copper-zinc, two molybdenum, one antimony and one zinc-lead, and four iron (magnetite) properties are known; but no gold-quartz veins of importance. Excepting for the copper-zinc properties on Mount Sicker, the production of metal from this part of the island has been small.

NORTHERN VANCOUVER ISLAND.

A small area of Palæozoic rocks has been recognized but most of the rocks have been mapped and described as belonging to three major groups; namely, Mesozoic greenstone and related rocks of the Vancouver group, granitic rocks of the Coast Range intrusives, and shale, sandstone, and conglomerate of the Cretaceous period.

Palæozoic Rocks.

The Palæozoic rocks have been mapped from Buttle Lake southward to Big Interior Mountain and Upper Drinkwater Creek, and consist principally of a thick series of andesite and basalt flows, tuffs, and coarse breccias. In the Buttle Lake area, the Palæozoic rocks include three interbedded limestone members and minor amounts of argillite and quartzite. In the Bedwell River area the several isolated masses of limestone are thought to belong to one horizon (Sargent, 1941, p. 17). Of these rock-types the limestone, though not the most abundant, serves as the best horizon-marker; rocks below it being Palæozoic in age, except for basalt intrusive into the limestone and granitic dykes, which are still younger. The basalt is probably related to the lowest member of Mesozoic volcanic rocks (Vancouver group) overlying the limestone. The granitic dykes are related to the Coast Range intrusion. The Palæozoic rocks have not yet been found elsewhere in the northern part of the island, but further mapping may show them to be of greater extent than known at present.

Mesozoic Rocks.

Vancouver Group.

Mesozoic rocks belonging to the Vancouver group are the most widely distributed on the island. These rocks include both volcanic and interbedded sedimentary rocks, but the volcanic rocks are the more abundant.

The volcanic rocks include both flows and pyroclastics. The flow-rocks range mainly from andesite to basalt; the more acid types such as dacite and rhyolite are not abundant. Andesites are the most abundant. They are dense to finely crystalline rocks, light to dark green in colour. The basalts are more black than green and are commonly amygdaloidal. Flow-structures, so common in the more basic rocks in Eastern Canada, are found, but are not common, in the Vancouver Island basalts. Greenstone intrusives are found commonly cutting the flow-rocks. The intrusives are lithologically very similar to the flow-rocks and are not easily distinguished from them. This similarity introduces problems in working out structure. Green to black porphyry dykes, some of which have distinct white feldspar laths up to 1 inch in length, cut the flow-rocks.

The volcanic fragmental rocks include breccias and tuffs. The breccias consist of green to grey, and frequently reddish, fragments, which range from ¼ inch to at least 2 feet in diameter. The larger fragments are set in a finer-grained ground-mass of similar colour. Bedding is seldom seen in the coarser fragmental types. Tuffs, representing the finer-grained equivalents of the breccias, range from grey-green to black rocks which may more properly be called tuffaceous argillites. The tuffs are very frequently well banded.

The sediments include limestone, argillite, quartzite, and tuffaceous argillite, variously interbedded with the volcanic rocks at different horizons. Of these rock-types, limestone is the most abundant. It ranges from finely to coarsely crystalline and from white to grey and buff in colour. Limestone-beds range from a few feet to 2,000 feet in thickness. The sediments are found in well-defined zones that may be traced for considerable distances, though individual beds are lenticular.

A threefold division of the Vancouver group has been made and found to be quite generally applicable to the northern part of the island. The division is made on the basis of those volcanics and sediments, the Karmutsen formation, which lie below a conspicuous limestone zone, the Quatsino formation, and those which lie above it, the Bonanza formation.

The Quatsino Formation.—Has been mapped mainly in the area from Zeballos north-westerly to Quatsino Sound. The formation consists of several hundred feet of fine- to coarse-grained crystalline limestone, dark grey to white and minor intercalations of green flows, and fine-grained grey or green tuffs. Massive grey-white crystalline limestone is the most abundant rock-type. It is a good marker and, as such, it is important in studying the areas along the west coast of the island.

Bancroft has noted that the Quatsino limestone is found, despite interruptions by intrusives, folding, and faulting, quite consistently 20 miles from the west coast, paralleling it from Quatsino Sound to Tlupana Arm, and he notes that other limestone south-easterly from Tlupana Arm and at the same distance from the west coast, may belong to the same formation. Limestone which may belong to the Quatsino formation is found on the Moyeha River, 20 miles from the coast on Flores Island, in the canyon 8 miles up Kennedy River from Kennedy Lake. Several scattered areas of limestone, much of which has been contact metamorphosed by adjacent intrusives, are found between the south end of Henderson Lake and Alberni Canal. It is possible that the Quatsino limestone may continue south-easterly across Alberni Canal as the Nitinat limestone, though probably offset by faulting and (or) folding.

Karmutsen Formation.—A great assemblage of volcanic rocks, which have been called the Karmutsen volcanics by Gunning (1931, 1932), lie below the Quatsino limestone. These consist of andesitic to basaltic flows, volcanic breccias and tuffs, and some interbedded limestone. In the Zeballos area, the flows are characterized by a large proportion of amygdaloidal and pillow lava. Flows, rather than pyroclastics, predominate.

Bonanza Formation.—A succession of flows, fragmental rocks, and interbedded sediments, collectively called the Bonanza group by Gunning (1931, 1932), lies above the Quatsino limestone. Amygdaloidal and pillow lava are not found in the Bonanza formation, instead massive, fine-grained, grey and green andesite and light-coloured types predominate among the flows. Breccias and tuffs are very abundant, crystal tuffs are common. The sediments include thin beds of limestone, argillite, and quartzite.

Coast Range Intrusives.

Rocks of the Vancouver group are intruded by stocks, dykes, sills, and irregular bodies of granitic rocks. These granitic rocks were probably intruded at the same time as those of the Coast Range batholith on the mainland. They have been referred to as " the Coast Range intrusives " by Gunning (1929). The larger bodies are accom-

panied by basic and acidic dykes. The Coast Range intrusives are not known to cut the Upper Cretaceous rocks.

In general the mineral deposits of Vancouver Island are in or close to Coast Range intrusives. For this reason the intrusives are important. It is immaterial whether the relationship of the mineral deposits with the intrusives is genetic or structural.

The Coast Range intrusives are well-crystallized rocks, granitic rocks, and include the following types: Granite, granodiorite, diorite, quartz diorite, and gabbro; quartz diorite and granodiorite being the most common. Quartz-porphyry and feldspar-porphyry dykes commonly found in the vicinity of the intrusives represent differentiates from the same parent magma as the larger bodies.

These intrusives are cut in many places by relatively late, green to black lamprophyre dykes.

The Coast Range intrusives have altered the adjacent wall-rocks to a varying extent, dependent on the nature of the wall-rock. The limestones are locally recrystallized to coarser-grained rocks and in places are replaced by contact metamorphic silicates such as garnet, diopside, and wollastonite. The volcanic rocks are less altered, and may be sheared, and only epidotized near a granitic contact. Argillites and quartzites have been mainly baked and sheared.

Tertiary Rocks.

In many places, bodies of igneous rocks have been observed cutting Upper Cretaceous sediments. These rocks include sills and irregular bodies of granodiorite and quartz diorite. They are usually much lighter in colour than the bulk of the Coast Range intrusives and tend to be porphyritic in texture, although even-grained types are found. It is possible that these rocks may be correlated with lower Oligocene intrusives of Sooke at the southern end of the island. In the northern part of the island the associated mineralization consists of small numbers of calcite stringers containing a little pyrite and chalcopyrite. Near Sooke a moderate amount of chalcopyrite mineralization is associated with Tertiary intrusives of gabbroic composition.

Structure.

The determinable structures of most importance in connection with the gold deposits on the island are found only in rocks of the Vancouver group. The Cretaceous rocks do not form the host-rocks for important deposits of lode-minerals and structures in these rocks are of no significance in a discussion of the lode-gold deposits. Structures in the Coast Range intrusives, apart from faults and shears, are too indefinite and indeterminable to be of use in the field.

Folds.—In general the rocks of the Vancouver group strike north-westerly and dip south-westward. However, variations from this strike and dip are common and are indicative of folds. The formation of these folds is related to forces accompanying the emplacement of bodies of the Coast Range intrusives. In general, the axes of these folds strike northerly or north-westerly; they may be vertical or slightly overturned. Both open and tight folds are found.

Folds of local development have been recognized and described for many areas. Tight folds which are slightly overturned to the east are common near Kathleen and Victoria Lakes in the Quatsino Sound area (Gunning, 1929); the formation of these folds has been definitely related to intrusives. It may be noted that important mineral deposits both of gold and copper are found in this vicinity.

In the vicinity of Nimpkish and Bonanza Lakes a large synclinal structure striking north-westerly is found (Gunning, 1929). Local intrusives have superimposed close folding and faulting on this larger fold.

In the vicinity of Buttle Lake the rocks are folded into a broad anticline pitching north, with two minor synclines on the anticline (Gunning, 1929). These folds are quite open with dips ranging from 30 degrees to less.

In the Zeballos area a tight syncline striking north-westerly is found along the Zeballos River (Gunning, 1932).

A minor syncline is reported from the head of Herbert Arm (Bancroft, 1937, p. 11.).

Sediments south of Della Lake in the Bedwell River area have been folded in a small open syncline whose axis trends north-westerly (Sargent, 1941, p. 26).

Faults.—Pre-mineral faults cut the folded rocks and associated batholiths, and in many places form major breaks and shear-zones, many of which are mineralized. Displacements range from a few feet to hundreds and perhaps thousands of feet. Attempts have been made to establish fault patterns and to establish a significance between the pattern and the local ore deposits.

SOUTHERN VANCOUVER ISLAND.

The geology of this part of Vancouver Island differs somewhat from that of the northern part. Some formations, present only in minor amounts in the northern part, are quite abundant in the southern, and some not represented in the northern are present in the southern.

Palæozoic Rocks.

Leech River Formation.—The oldest rocks are Palæozoic in age and comprise the Leech River formation. This formation consists of a metamorphic group of schistose, fine-grained sediments, associated with which is a series of volcanics, largely fragmental, described as the Malahat volcanics. The Leech River rocks are considered to be of Carboniferous age, but are of different type from the Palæozoic rocks of the Buttle Lake area, and definite evidence of their Palæozoic age is lacking.

The Leech River rocks are thought to be overlain by Mesozoic rocks of the Vancouver group.

Mesozoic Rocks.

Vancouver Group.—As in the northern part of the island, a threefold subdivision has been made of the Vancouver group into a middle limestone member, the Sutton formation, and lower member, the Vancouver volcanics, and upper member, the Sicker series. A widespread limestone member, the Nitinat limestone, described as being not definitely Mesozoic and possibly Palæozoic in age, is found on the west coast and is also included with the Vancouver group.

The rocks of the Vancouver group in the southern part of the island are lithologically similar to the volcanics, sediments, and limestones of the same group in the northern part of the island.

The Sutton formation consists of numerous lenses of limestones, up to 600 feet thick, which are intercalated with upper beds in Vancouver volcanic members. Bodies composed of contact metamorphic silicates have been formed in the limestone close to intrusive rocks.

Sicker Series.—The Sicker series consists of both volcanics and overlying metamorphosed sediments, closely associated with acidic and basic intrusive rocks. The acidic intrusives are known as the Tyee quartz-feldspar porphyry and the basic intrusives as the Sicker gabbro-diorite porphyry. The volcanics are mainly andesitic rocks. The sediments comprise cherty tuffs and black slates.

Coast Range Intrusives.—The Coast Range intrusives include a variety of igneous rock-types. These have been studied in considerable detail in the Sooke and Duncan areas and subdivided into several group (Clapp, 1913 and 1914; Clapp and Cooke, 1917).

Detailed studies of these rocks in the area south of Duncan reveal that they were intruded in a definite sequence which resulted in rocks that range from basic to acidic in composition. This sequence of igneous rock-types includes the Wark gabbro-diorite gneiss, the Colquitz quartz-diorite gneiss and the Saanich granodiorite.

The Wark and Colquitz gneisses are local and form a single batholith extending from Shawnigan Lake to Victoria.

The Saanich granodiorite is of largest areal extent and forms many small batholiths and stocks from Alberni Canal south-easterly to the southern end of the island. A basic phase, the Beale diorite, is closely associated with the Saanich granodiorite where it intrudes the Nitinat formation. The Beale diorite forms around the periphery of the granodiorite, and inasmuch as it is commonly brecciated by the granodiorite it probably was intruded before the granodiorite.

The Tyee quartz-feldspar porphyry and Sicker gabbro-diorite porphyry are confined to the Sicker series and form sills, dykes, and irregular masses in these rocks. Much of the Tyee quartz-feldspar porphyry has been altered to sericitic schist.

Gabbro and anorthosite intrusives, known as the Sooke gabbro, cut Tertiary volcanic rocks at the southern end of the island. The Sooke gabbro forms four stocks between the south end of Sooke Lake and the south tip of the island.

Cretaceous Rocks.

Upper Cretaceous sediments, comprising conglomerates, sandstones, and shales, are widely developed along the eastern coast of the island, but are confined largely to two basins, a southerly, the Cowichan basin, and a northerly, the Nanaimo basin. These Cretaceous rocks contain the coal-seams found on the island.

Tertiary Rocks.

Eocene Metchosin Basalt.—A thick series of basalts of Eocene age, termed the Metchosin volcanics, is found at the southern end of the island.

Tertiary Sediments.—Coarse detrital sediments Oligocene to Miocene in age are found on the coastal plain that extends along the west coast and around the southern end of the island.

Structure.

The Leech River slates have been closely folded into folds that strike east-west.

As in the northern part of the island, rocks of the Vancouver group have been deformed into folds that in general strike north-westerly. However, local variations from this general trend of the folds are found.

Two major synclines trending north-westerly have been described from the Duncan and Sooke areas. The south-westerly syncline involves rocks of the Leech River, Malahat, Vancouver, and Sutton formations and the north-easterly rocks of the Sicker series.

The Cretaceous rocks have also been folded, but, inasmuch as Cretaceous rocks do not form the host-rocks for any of the gold ores, folds in these rocks are of no significance in searching for lode gold.

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CHAPTER III. LODE-GOLD DEPOSITS AND FAVOURABLE PROSPECTING AREAS.

Recent lode-gold production on Vancouver Island has come principally from gold-bearing quartz veins. Copper-zinc replacement deposits at Mount Sicker have produced by-product gold and silver in important quantity and formerly produced most of the island's precious metal. Gold-bearing quartz veins have been found in the western part of the island, principally in the Zeballos River, Bedwell River, and Herbert Arm areas, and there are more scattered occurrences between these areas and north of Zeballos. Veins have also been found east of Alberni Canal and west of Nanaimo.

GENERAL FEATURES OF A FAVOURABLE PROSPECTING AREA.

Study of the various gold-quartz veins on the island has revealed many common features of occurrence, a knowledge of which may be used in future prospecting on the island. The writer will therefore preface a more detailed discussion of the geology and deposits with some general conclusions about the occurrence of gold-quartz veins on the island in relation to the batholith areas and will present ideas about prospecting near them.

Most of the gold veins on the island, and elsewhere, are found either in or close to batholiths or stocks of granitic rocks. Because of this common association of gold-quartz veins and intrusive rocks the gold-bearing solutions from which the vein-matter was deposited must have originated either from the associated, visible intrusive rocks or from a common source much deeper in the earth's crust. The actual source is hard to prove, and although some visible granitic rocks close to quartz veins in Eastern Ontario have been proven to be the source of the vein solutions, a source much deeper within the crust is most generally accepted as the more probable. Whatever the actual source, the close relationship of gold quartz to small batholiths and stocks is almost universal. Therefore, where an area is characterized by small batholiths or stocks of granitic rocks conditions may be assumed to have been favourable for the production of vein solutions either from the visible igneous rocks or from deeper in the crust at that point. It is necessary then to find an environment of rock-types in or close to areas of intrusive rocks that will give breaks or fractures suitable for the deposition of vein-matter from the vein solutions.

Breaks, either fractures or shear-zones, which veins may follow tend to form where rock-types of different competency or physical characteristics are found. The breaks may follow or may cross the contacts of the different rock-types. Breaks which cross contacts may differ in the different rock-types. A break may be a wide shear-zone in a weak rock such as schist or schistose greenstone but may be a narrow shear in a stronger rock such as a granite.

Rocks of different physical characteristics are more apt to be found in the contact areas of batholiths. In such areas not only the batholith itself is in contact with the older rocks but the many stocks and dykes accompanying the batholith cut the older rocks. On the batholith side of the contact the older rocks may be found as inclusions or pendants in the batholith. Therefore, within a batholith, if not too far from the contact, a physical contrast in rock-types is found.

It may be noted that on the outer side (outwards from the batholith) one may prospect at considerable distances from the contact and still not be far above the actual batholith. An area which is close to a batholith, either horizontally or vertically, is usually characterized by numerous dykes and small stocks of granitic rocks, mainly feldspar or quartz porphyries, that are related to the main batholith. The porphyry dykes, cutting the older rocks (frequently greenstone on Vancouver Island), achieve the contrast in physical features of rock-types necessary for the formation of good breaks. This desired contrast in physical features tends to extend farther into the greenstone area from the batholithic contact than into the main mass of the batholith. In relation, therefore, to batholith contacts, favourable prospecting areas extend farther into the area of older rocks than towards the centre of the batholith.

Experience has shown that the full length of any contact-zone will not be productive. After a mining camp has been established and numerous underground workings are available for study, correlation of surface studies with studies of the underground workings is frequently able to demonstrate why a concentration of producers is found at one place and not at others along the contact-zone. But until such time as the controlling factors have been recognized there may be little to guide the prospector to the more favourable sections of a contact-zone.

One of the best ways in prospecting is first to study the known ore-deposits in the mineralized area nearest to the area to be prospected. A study of the mineralogy, structure, and rock associations of proven gold deposits should be made, so that search for duplicates of favourable conditions, if only in part, can be made intelligently in undeveloped areas. A knowledge of how veins look when high grade, marginal, or non-economic is also of value to the prospector. With this in mind, the writer describes the geology and gold deposits of the various mineralized areas on the island in some detail, so that the prospector or scout may have the pertinent information on the areas nearest to the area he intends to prospect.

DESCRIPTION OF MINERALIZED AREAS.

Properties North of Zeballos.

In general, copper and lead-zinc, rather than gold prospects, have been discovered in this area. About fifteen copper and five lead-zinc and three or four gold prospects have been reported.

On the *Quatsino King* property on the western side of Neurotsos Inlet a north-westerly-trending zone or stockwork of quartz veinlets cuts a variety of greenstones. The stockwork consists of many closely spaced quartz veinlets over a width of 16 feet and a known length of about 300 feet. The quartz contains small amounts of pyrite, sphalerite, and chalcopyrite, and a little gold. The wall-rock consists of greenstone tuff and breccia cut by numerous granodiorite dykes. The gold values in this deposit, as developed to date, are low. At one time the Granby Consolidated Mining, Smelting and Power Company, in search of siliceous flux for their Anyox smelter, did exploratory work on this deposit hoping that the quartz would carry enough gold to pay for mining and handling.

At the *Fil* property, on Deep Inlet near Kyuquot, at least five different quartz veins have been found in granodiorite. These veins range in width from 6 to 24 inches and contain varying amounts of mixed sulphides. Free gold is visible in places, particularly where the veins are oxidized. The property has been under development for the past three years. No reports of ore shipments have as yet been made.

Zeballos Area.

The general geology of the area has been described by Gunning (1932) and Bancroft (1940). A geological map on a scale of 1½ miles to 1 inch accompanies Gunning's report.

The main gold-producing properties and many other non-producers have been described by Bancroft (1937 and 1940), Stevenson (1935 and 1939), Stevenson and Maconachie (1938), and Patmore (1938). Much of the following discussion has been abstracted from these publications; however, the present writer accepts responsibility for the generalizations made about the ore-deposits and particularly about suggestions for prospecting.

Location and Access.—Zeballos is a small mining community on the western coast of the island, about 195 nautical miles north-westerly from Victoria. The Canadian Pacific Steamship Company maintains a tri-monthly service from Victoria or Port Alberni up the western coast and calls in regularly at Zeballos. When business warrants, planes of the Canadian Pacific Airlines fly from Vancouver to Zeballos, and when mining activity was at its height, regular mail-plane and radio-telephone services were maintained between Vancouver and Zeballos.

The Zeballos lode-gold area at present includes the valley of the river and its watersheds. The area in which the most important properties have been found lies in the angle between the main Zeballos River and the Nomash River and an east-west line 1½ miles northerly from tide-water; this area includes the valleys of Van Isle, Spud, and Gold Valley Creeks and the headwaters of the Little Zeballos River.

Access within the immediate area is by a truck-road which leads up the main river valley 4½ miles to *Privateer* mine and then for 2½ miles to *Mount Zeballos* and *Spud Valley* mines. From the *Privateer* it goes for 3 miles to the *Central Zeballos* mine. The road extends for about a mile beyond the *Central Zeballos* and from the end of it trails lead up the North Fork and up the Nomash (South Fork) Rivers.

Topography.—The country is extremely rugged. The hillsides are heavily wooded but steep, and often the dense growth of timber serves only to obscure unscalable rock bluffs. The floor of the main valley, where not bluffy, ranges from one-eighth to one-half mile in width. The tributary creeks flow in narrow valleys and join the main valley on steep gradients ranging from 600 to 800 feet per mile.

Mining History.—Although small amounts of placer had been obtained from the Zeballos River as early as 1907, it was not until 1924 that the first gold vein, on the *Tagore* property, was staked. Two years later the *King Midas* was staked, and by 1929 forty claims had been staked in the valley. In that year the first shipment of ore was made from the valley. It consisted of 2 tons of high-grade ore, mined from the *Tagore*. A period of inactivity followed until 1934, when the first of the rich gold-quartz veins that were to make the Zeballos camp an important producer in a very short time were found.

Lode-gold mining really began in the winter of 1934–35 with shipments of high-grade ore from the property of the White Star Gold mines. In 1936 the main high-grade vein on the *Privateer* was found and shipments of high-grade ore were made from it in 1937. Milling started in standard-sized mills later. In 1938 the *Privateer* 75-ton amalgamation-cyanide mill and Spud Valley Gold mines 50-ton amalgamation-flotation mill began operating. The tonnages of these mills were stepped up to 85 and 70 tons respectively in 1938. In 1938, thirty properties, employing nearly 400 men, were active in prospecting, development-work of actual mining. In 1939 a 50-ton mill was built at the *Mount Zeballos*, and a 40-ton mill at the *Central Zeballos* and in 1941 a 25–50 ton mill at the *Homeward*. About the middle of 1942 shortage of men and supplies because of war forced all but the *Privateer* and the *Prident* to close down, and in October, 1943, these properties also were forced to close " for the duration."

Production.—Gold-quartz ore mined from fifteen properties in the Zeballos area has amounted to a total of 344,668 tons. Of this total, 335,000 tons came from four properties for which production has ranged from 35,000 to 137,000 tons, and the remainder from properties with production ranging from 1 ton to a few thousand tons. The total gold recovered has amounted to 261,468 oz., an over-all average of 0.76 oz. per ton mined, and has ranged from 0.4 to 5 oz. per ton. Silver has been recovered approximately in the ratio of 1 oz. silver to 2½ oz. gold. The returns for ore, shipped from several properties to the smelter, have included credit for lead and in some cases for copper.

Geology.—The general geology of the region has been described by Gunning (1932). The main feature of the geology is a north-westerly-south-easterly trending belt of granitic rocks, called by Gunning the Zeballos batholith. The rocks range in composition from gabbro to quartz monzonite, but within the area under consideration quartz diorite is most common. The batholith ranges in width from approximately 2 miles near the headwaters of Gold Valley Creek to three-quarters of a mile where it crosses the Zeballos and widens out from there as it extends north-westerly from the river. The Zeballos batholith has intruded Mesozoic volcanics and sediments of the Vancouver group that Gunning has divided into three groups—a lower assemblage of volcanic rocks called the Karmutsen volcanics; a middle limestone member, the Quatsino limestone, both groups lying north-east of the batholith; and an upper volcanic group, the Bonanza group, lying south-westerly of the granodiorite. These rocks are similar to those found elsewhere on the northern part of the island and have already been discussed on pages 9–12 of this publication.

To date the greater number of properties lie within either the quartz diorite or the volcanics and associated sediments along the south-western contact. There are a few properties, however, in the volcanics at distances from 2 to 3 miles from either contact.

Gold Deposits.

High temperature replacement deposits of iron and of copper and gold-quartz veins are found in the Zeballos area. The copper deposits are small and unimportant. One large and several smaller magnetite (iron) deposits have been found which may prove to be of considerable importance. However, because this publication is concerned only with lode-gold deposits, the copper and iron deposits will not be described.

Strike Groups.—Nearly all the gold-quartz veins in the Zeballos camp strike in the north-east quadrant. They are either vertical or have very steep dips. On the basis of their strike, the veins may be divided into three groups; both the group that strikes easterly and the group that strikes north-easterly include important producers; a third group consists of veins striking nearly north-south; these are outside the main productive area and have not produced.

The veins in the easterly-striking group range in strike from 10 degrees north of east to 7 degrees south of east, and in dip from vertical to steep northward or southward. This group includes the veins on the *Privateer, Prident, Central Zeballos, Rimy, Homeward,* and *Monitor* properties, of which the *Privateer* and *Prident* are close to the western contact of the Zeballos batholith and the remainder are near the eastern contact. All these properties, excepting the *Monitor,* have produced gold, three of them over 1,400 oz., and the total production has been 165,067. One of them, the *Privateer,* has been the major producer in the camp.

The veins in the north-easterly-striking group ranging in strike from north 30 degrees east to north 55 degrees east, and dipping steeply on either side of the vertical, are found in three main areas. In the greenstone area south-west of the main Zeballos batholith, north-easterly-striking veins are found on the *Tagore, Van Isle,* and *Friend* properties. On the quartz-diorite side of the western contact north-easterly-striking veins are found on the *Prident, White Star, Zeballos Gold Peak, Spud,* and "*M*" and *Mount Zeballos* properties. These properties include the important producers of the north-easterly-striking veins, four of the properties have a combined gross production of more than 143,000 oz. of gold. Towards the centre of the batholith north-easterly-striking veins are found on the *B. and Wet* claims, *Rey Oro, I.X.L.,* and *Big Star* properties.

Neither group of veins possesses any easily discernible common relationship to the structure, texture, mineralization, or wall-rock.

The main producing veins of the camp are: Easterly-striking veins found close to both the west and east contacts of the batholith, and north-easterly-striking veins found close to the south-west contact. To date the largest production has come from veins of both groups near the western contact, either in the greenstone or in the granite.

Vein-structure.—Most of the gold-bearing veins consist of quartz-sulphide filling in well-defined fault-fissures, rarely more than a foot wide, that maintain a fairly uniform strike and dip over considerable distances. In places the quartz-sulphide vein-matter may be lacking, and only sheared rock present. The walls of the quartz-sulphide veins are marked by films of gouge; frozen walls are not common.

Some of the gold-quartz veins occur in sheeted zones up to 4 feet wide. These zones consist of joints spaced 2 to 8 inches apart and contain either gouge films or ⅛ to 1 inch quartz-sulphide stringers. Along the strike a sheeted zone may change into a single, narrow shear containing a lenticular vein of quartz sulphide. The Goldfield vein on *Spud Valley* property is an example. Sheeted zones are not common.

Wide shear-zones containing mineralized veinlets of quartz are not common. However, a shear-zone about 100 feet wide has been found on the *Big Star* property of the Spud Valley Gold Mines, Limited, and promises to be of some importance.

Vein-texture.—Most of the Zeballos gold-quartz veins are banded either by an alternation of quartz and sulphides or by an alternation of the different sulphides themselves. Comb-texture, so called because of the comb-like appearance of pyramid-shaped quartz crystals that project inward from either side of the band, is common. The spaces between the crystals are commonly filled with sulphides.

The vein-filling consists of quartz, some carbonate, and sulphides. The sulphides, though in some veins unimportant, are very abundant in most of the Zeballos veins. They range from a small fraction to one-half of the vein-matter, and probably average about one-quarter of the vein-matter.

Listed in order of abundance the sulphides are pyrite, sphalerite, arsenopyrite, chalcopyrite, galena, and pyrrhotite.

Occurrence of Gold.—Gold is visible in much of the vein-matter, but commercial ore may contain no gold recognizable with the unaided eye. Specimens of crystalline gold have been found at *Privateer* and *Spud Valley* mines. Large masses of hackly gold have been found on the *Privateer*.

The distribution of the gold is fairly constant. In the quartz sulphides the amount of gold is not only proportional to the sulphide content, but is also dependent on the presence of sphalerite and galena. The reason is not obvious. It is most likely that the gold, though slightly later in time of deposition, came in with the surge of mineralization that brought in the galena and sphalerite. The galena and sphalerite, though not necessarily abundant, are nevertheless significant as indicators of gold. Quartz veins that contain either abundant pyrite, or arsenopyrite, or pyrite alone, do not as a rule contain much gold.

Zones of crushed rock which may lie immediately adjacent to gold-bearing veins, and which may contain disseminated crystals of pyrite, are usually very low in gold. Good gold values are not found in the crushed rock and gouge of a shear-zone even though found in quartz-sulphide ribbons or lenses of the same shear-zone.

The wall-rock of the veins contains no gold of economic importance.

Suggestions for Prospecting.—The present producing area is in, and close to, the part of the Zeballos batholith that lies south-east of the Zeballos River. In this section the batholith is about three-quarters of a mile wide. To the north-westerly it widens to 4 miles in the Kaouk River Valley and to the south-east it widens to 2 miles near the head of Spud Valley Creek. The areal extent of the batholith is unknown north-easterly beyond the Artlish River and also relatively unknown south-westerly beyond the head of Spud Valley and Gold Valley Creeks.

A fair amount of prospecting has been done north-west of the Zeballos River in the Kaouk and Artlish River Valleys, but without any marked success. However, the country is very rugged and difficult of access, so that the amount of time spent in actual prospecting for quartz veins is small in proportion to the time spent in travel and in the back-packing of supplies.

South-easterly from the Zeballos River the extension of the batholith has been prospected, at least as far as the Little Zeballos River. Though perhaps less so than the Kaouk-Artlish country, this section is still difficult of access, everything having to be back-packed from tide-water. For this reason the entire section has not been thoroughly prospected in the few years since the Zeballos area came into prominence.

The properties from which ore has been mined are near the north-eastern contacts of the Zeballos batholith, south-easterly from the constriction of the batholith at the Zeballos River, with most of the production coming from the south-western contact. These facts suggest that the most favourable prospecting ground lies south-easterly from the river, along both contacts of the batholith, but preferably along the south-western contact. It may be that gold-quartz veins as rich as those already known will not be found until another constriction in the batholith is found. However, should the batholith taper to a point in going south-easterly the tapering might be as favourable as a constriction on the localization of rich gold-quartz veins.

The writer would suggest the prospecting of the south-easterly extent of the batholith, either from the Little Zeballos side or from the Nomash (South Fork, Zeballos River) side. It is not necessary to stay close to the area of batholithic rocks. Greenstone cut by late dykes, granitic or otherwise, is sufficiently heterogeneous in physical characteristics, and therefore in response to fracturing forces, to induce the formation of breaks suitable for vein-formation. (*See* pages 14–15 of this publication for a discussion of favourable prospecting ground.)

It may be that the localization of the rich gold-bearing veins between the head of Spud Creek and the Zeballos River is related, directly or indirectly, to some feature transverse to the batholith, either to a north-south pre-mineral line of major faulting or weakness or to a transverse depression in the original roof of the batholith. However, even if this proves true, it is still worth while to prospect the continuation of the batholith area for a repetition of whatever transverse conditions caused the localization of the known gold deposits.

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——— (1940): Some observations in ore search: Privateer Mine, Zeballos, B.C.—*Trans. A.I.M.E.* T. P. 1209.

STEVENSON, J. S., and MACONACHIE, R. J. (1938): The Zeballos area—*Minister of Mines, B.C.,* Ann. Rept., pp. F 41–F 65.

NOOTKA SOUND AREA.

Zinc, copper, and iron properties have been found in this area, but so far only one gold property, the *Baltic* group, on the south side of Muchalat Arm. Between 1934 and 1938 over 100 tons of gold ore, averaging slightly over 1 oz. gold to the ton, were shipped from this property, then owned by the Danzig Mines, Inc. The main vein is 4 to 12 inches wide, and strikes north-north-easterly in granodiorite. The mineralization consists of pyrite, chalcopyrite, sphalerite, a little galena, and pyrrhotite.

Reference.

BANCROFT, M. F. (1937): Gold-bearing deposits on the west coast of Vancouver Island between Esperanza Inlet and Alberni Canal—*Geol. Surv., Canada,* Mem. 204, pp. 18–20.

HERBERT ARM AREA.

Location, Access, and Names of Properties.—Herbert Arm is reached by Canadian Pacific steamer from Victoria or Port Alberni to Ahousat, then by launch for 12 miles to the head of the arm. Most of the properties are close to tide-water, at the head of the arm.

The properties on which gold-bearing veins have been found include the *Abco, Big Boy, Moyeha,* and *Tyee.*

History.—This area first became active in 1933 when the gold finds were staked. Prospecting and development-work continued until 1935, but since then little has been done. In 1938 the Premier Mining Company took over the *Abco* and employed a crew of sixteen men doing repair and exploratory work. In 1941 a small shipment of ore was made from the *Big Boy.*

Production.—The total production from the two producers, the *Abco* and *Big Boy,* has amounted to 135 tons, containing 334 oz. of gold.

Geology.—On the Herbert Arm properties gold-bearing quartz veins, both of the replacement and fissure type, occur in greenstones that have been cut by acidic dykes and irregular masses of granitic rocks.

Quartz Veins.—Quartz is the predominant vein-filling and sulphides, including pyrite, chalcopyrite, and galena, are present, but seldom in large amounts. The veins differ from the Zeballos veins in the smaller sulphide content.

Both simple-fissure and shear-zone deposits are found. Production has come from a narrow shear-zone striking north-westerly on the *Big Boy* and on the *Abco* property from a wider shear-zone, which strikes north-easterly. The *Abco* shear-zone, at least 4 feet wide, contains parallel quartz veins, which seldom exceed 8 inches in width. The wall-rock does not carry gold so that selective mining of the high-grade vein-matter is necessary.

Suggestions for Prospecting.—The area at the head of Herbert Arm has not been mapped geologically, so that the relative extent of greenstone and batholithic rocks is unknown. However, the presence of many feldspar-porphyry dykes suggests that the batholithic rocks are close. A tongue of granodiorite, possibly part of the Penny Creek intrusive, is reported to extend from the Bedwell River area to the Cotter Creek slope, which would be only about 2 miles from the head of the arm. Prospecting in this direction would lead towards the intrusive and in so doing probably would go through areas of greenstone cut by abundant porphyry dykes; if so, the area easterly would be likely prospecting ground.

The north-westerly extension of the main Bedwell River batholith crosses the Moyeha River probably about 8 miles from the head of Herbert Arm. It is doubtful if prospecting would yield much except near the batholith, and it is uncertain where, along the contact-zone of the batholith, one may find a repetition of the gold-quartz mineralization found in the Bedwell River section.

Because the distances between accessible points are shorter and problems of transportation less, the writer would suggest working north-westerly from the head of the arm towards the head of Shelter Inlet, a distance of about 6 miles, and south-easterly towards the head of Bedwell Sound, also about 6 miles. The presence of small quartz veins, carrying a little gold, in granodiorite on the *High Boy* property on Shelter Arm, indicates the existence of gold mineralization in this direction. Numerous gold-quartz veins have been found in the Bedwell River area; these are to be discussed shortly.

When considering prospecting up the Moyeha River towards the Bedwell batholith it is to be remembered that the absence of a road and good pack-trail necessitates spending much time back-packing supplies.

References.

BANCROFT, M. F. (1937): Gold-bearing deposits on the West Coast of Vancouver Island —*Geol. Surv., Canada*, Mem. 204, pp. 20–25.

STEVENSON, J. S. (1935): Vancouver Island, Herbert Arm section—*Minister of Mines, B.C.*, Ann. Rept., pp. F 40–F 46.

BEDWELL RIVER AREA.

The geology and ore-deposits of the Bedwell River area have been described in detail in two bulletins by Sargent (1940 and 1941). The following discussion represents an abstract of the information contained in these bulletins, with some generalizations contributed by the present writer.

Location and Access.—The Bedwell River area is on the western coast of the island, about 70 miles down the coast from Zeballos or 20 miles up the coast from Clayoquot and Tofino. The Canadian Pacific Steamship Company maintains tri-monthly service from Victoria and Port Alberni up the coast to and beyond Clayoquot and Tofino. Passengers and freight are conveyed in launches and scows from Tofino.

A truck-road extends for about 7 miles up the river and serves the *Musketeer* and *Buccaneer* properties. Trails lead from the end of this truck-road to the various

properties and a trail continues up the main valley to the *You* and *Casino* properties. It is possible to follow a difficult route over Bear Pass to Della Lake and thence to Drinkwater Creek. The *Big I*, *Della*, and *Sherwood* properties are in this section. However, these latter are reached more easily from the Drinkwater Creek side by a route from Port Alberni via 10 miles of road to Great Central Lake, thence by boat up the lake. From the western end of the lake transportation may be arranged on the logging-railroad of Bloedel, Stewart & Welch for 3¾ miles and then a pack-horse trail followed for 4½ miles to the *Sherwood* base camp.

Topography.—As is characteristic of the western coast, the Bedwell River area is rugged and mountainous. The valley-bottom of the Bedwell River is on the average about one-quarter mile wide and excepting for about 1½ miles at its mouth has an average gradient of about 80 feet per mile. Most of the tributary streams are in deep narrow canyons. The forest-cover of conifers is abundant and mining timber plentiful.

History.—As has been the case elsewhere, the discovery of lode-gold deposits in this area was preceded by placer-mining on the Bedwell River. Chinese worked gravels on the river for placer gold as early as the '60's, but appear to have left the country in the '80's.

Several years later, between 1898 and 1903, gold-quartz veins and copper replacement deposits were found at several places between the mouth of the river and Big Interior Mountain at its head. Locations during this period include the *Seattle*, *Annex*, *Belvidere*, *Galena*, *Avon*, *Prosper*, and the part of the present *Musketeer-Buccaneer* ground covered then by the *Corona* claim.

Activity was slack in the period 1903 to 1912. In 1912, English interests purchased copper claims on Big Interior Mountain, covering discoveries made as early as 1899. Work was started on the construction of a road up Bedwell River Valley to connect with a proposed aerial tram down the mountain from the showings. Only 7 miles of the 13 miles required had been built when work was stopped at the outbreak of World War I. With the exception of some diamond-drilling in 1916, very little further work has been done on the copper showings.

Excepting work on the *You* property, very little was done in the area between 1914 and 1938. In 1933 a small cyanide-mill was built on the *You* property, but shortly after the mill had been built two large bridges across the Bedwell River washed out, thereby destroying access by road to the *You*. Consequently operations on the property ceased.

In 1938, probably as a result of the discoveries just made in the Zeballos area, interest in the area was renewed. Prospectors were very active during 1938 and 1939, many gold-quartz veins were found, and much of the ground extending up the river and over the divide into Drinkwater Creek was staked.

In 1938 the *Musketeer* and *Buccaneer* properties were located and between 1938 and 1939 were optioned by Pioneer Gold Mines, Limited, and Anglo Huronian Company, Limited, and by Bralorne Mines, Limited.

Underground work was done, mainly on the *Musketeer* and *Buccaneer*, and mills were built on these properties. Largely because of the shortage of labour and materials as a result of World War II., operations at most of the properties had ceased by July, 1942.

Production.—The production from the Bedwell River area has been mainly from the *Buccaneer* and *Musketeer* properties, although a small tonnage was produced from the *Della* and *Sherwood*. Over the producing period of two years, 1941 and 1942, the production amounted to 10,059 tons of ore, from which about 5,000 oz. of gold were recovered. The grades of mill-feed over yearly periods averaged between 0.26 and 0.84 oz. of gold per ton.

Geology.—A summary discussion of the distribution of rock-types follows, but for more detailed knowledge the reader should refer to the description and coloured map on a scale of 1 mile to the inch in Bulletin No. 13 by Sargent (1940).

Greenstone is found from the head of Bedwell Sound for about 1½ miles upstream as far as Penny Creek. Here a tongue of granitic rocks, 1¾ miles wide on the western side of the main valley, extends for an unknown distance north-westerly in the direction of the head of Herbert Arm. Greenstone again is found from near Penny Creek up the main valley for about 2½ miles to the south-western contact of the Bedwell batholith just beyond Noble (Clarke) Creek. The greenstone belt extends an unknown distance north-westerly and south-easterly, where cut by the river the batholith is 6 miles wide, extending to the slopes and summit of Big Interior Mountain. The batholith extends an unknown distance north-westerly and south-easterly. A large area of greenstones and limestone extends easterly from the batholith, continuing beyond the eastern boundary of the area mapped geologically.

Replacement Deposits.—Copper-bearing replacement deposits, which do not carry enough gold to make that metal an important part of any possible production, have been found in two localities. The deposits consist of limestone lenses which, near bodies of granitic rocks, have been replaced by silicates and sulphides. Pyrite, chalcopyrite, sphalerite, and magnetite are the common sulphides. Copper replacement deposits are found on the *Avon, Seattle,* and *Galena* properties, close to an area of intrusive rocks mapped as the Penny Creek intrusive. Chalcopyrite is found replacing volcanic rocks and limestone on the *Ptarmigan* and *Big I* properties on Big Interior Mountain. So far, development-work has not disclosed commercial ore-bodies of either copper or of copper and gold.

Gold Deposits.

The Bedwell River area is important because of its gold-bearing quartz veins. Gold-quartz veins have been found on fourteen properties, and on two properties—the *Musketeer* and *Buccaneer*—moderate tonnages of ore have been mined and milled.

Strike Groups.—The gold veins all strike in the north-easterly quadrant. They fall into two groups, those striking close to north 20 degrees east and those with strikes close to north 65 degrees east. On any one property veins of two strike groups may be found. Veins of the first group are found on the *Musketeer, Buccaneer, Avon, Noble* and *Noble B, Casino, Della, P.D.Q.,* and veins of the second group are found on the *Musketeer, Trophy, Thunderbird, Prosper, O.K., You, Casino,* and *Sherwood.* Veins from both strike groups contain high-grade gold-bearing quartz and have produced ore.

Concerning dips of the two strike groups, Sargent (1940, p. 28) has made the observation that veins of the strike group north 20 degrees east are nearly vertical or dip steeply eastwards in the western part of the area and dip less steeply westward in the eastern part. He also observes that almost all the veins of strike group north 65 degrees east seen by him dip from 45 to 70 degrees northward.

Structural Types.—Most of the quartz veins belong to one of the three following structural types, simple fissure-veins, sheeted zones, or wide shear-zones.

Simple fissure-veins are characterized by a single quartz vein which is usually bordered by a film of gouge or a narrow width of sheared wall-rock. Veins with frozen walls do occur but are not common.

A sheeted zone consists of several parallel or sub-parallel fissures, over a width of 1 foot to several feet, which have been filled with narrow quartz stringers ranging from a fraction of an inch to a few inches wide. Along strike a sheeted zone may grade into a narrow shear containing a single quartz vein.

The shear-zone type of deposit consists of one or perhaps two lenses or lenticular veins of quartz lying in a zone of sheared rock, which is usually several times the width of the contained quartz vein-matter.

Simple fissure-veins, veins in sheeted zones, and veins in wide shear-zones are found at various places in the area. Simple fissure-veins are the most common and have been found on the *Musketeer, Trophy, Thunderbird, Noble* and *Noble B, O.K.*, and *Casino*. Sheeted zones of several narrow quartz veins are found on the *Thunderbird* and *Musketeer*. Veins in shear-zones are found on the *Buccaneer, Sherwood, Della, Prosper*, and *Avon*.

Many of the veins have branches which lead from the main vein into the walls. The vein-matter is usually wider than average at the junction of the branch and main vein.

Vein-texture.—Much of the quartz in the gold veins of the area is in narrow plates separated by thin partings or layers of pulverized wall-rock or vein-matter, either as gouge or cemented by later vein-filling, and may contain a concentration of sulphides. Partings parallel the dip and strike of the vein.

A common type of vein-matter consists of large, well-shaped quartz crystals surrounded by abundant sulphides. This material is only loosely coherent and can be easily shattered by a hammer-blow. In some veins most of the quartz crystals are arranged roughly perpendicular to the walls of the vein and produce a comb-like texture in the vein-matter. Massive white quartz without characteristic texture is found in some veins, but ribboning and often a loosely aggregated texture is characteristic of most of the veins.

Vein-matter.—The vein-matter consists of quartz, carbonates, and sulphides. The sulphides include pyrite, sphalerite, chalcopyrite, and galena. Pyrrhotite and derived marcasite are found in some veins.

Arsenopyrite in an appreciable amount has been found in a vein near the eastern and in another vein near the western contact of the Bedwell River batholith.

The total amount of sulphides in the vein-matter ranges up to at least 50 per cent. "Although the gold is associated with the sulphides, between pieces of vein-matter which give the same gold assay there may be a marked difference in sulphide content; this statement applies to mineralization from the same vein but the difference is more striking when mineralization from certain near-by veins is compared." (Sargent, 1941, p. 23.)

It may be noted that whereas the sulphide content of better sections of the *Musketeer* veins ranges from 3 to 10 per cent. of the vein-matter, the better sections of the *Buccaneer* veins average a fraction of 1 per cent. The *Musketeer* and *Buccaneer* veins differ not only in total sulphide content but also in the proportions of the different sulphides present. Concerning the two properties, Joubin (1942, p. 9) says that in most of the veins on the *Musketeer* the main sulphides are pyrite, sphalerite with minor amounts of chalcopyrite and galena, whereas in the veins on the *Buccaneer* the main sulphides are chalcopyrite and galena, with very minor amounts of pyrite and sphalerite.

In general it may be said that the richest veins are those high in sulphides, in which both galena and sphalerite are present. Though the galena and sphalerite may not be as abundant as pyrite in a rich gold vein, they still are in appreciable quantities. Quartz veins in which pyrite is the only sulphide do not so frequently carry good gold values. In general, to carry good gold values a vein needs galena and sphalerite in addition to pyrite.

The wall-rock of the veins is seldom mineralized by sulphides and does not carry important gold values. It is frequently bleached for several inches on either side of the vein. This bleaching is most common if the wall-rock is sheared and if it is greenstone rather than quartz diorite.

Rocks associated with Gold Veins.—The gold-quartz veins of the area are found in granitic rocks of the Bedwell River batholith or of the Penny Creek intrusive mass, in greenstones, or along and close to contacts of the two rock-types and in combinations of these rock-types.

Veins in which the wall-rock is quartz diorite, the prevailing granitic rock in the area, are found on the *Musketeer, Trophy, Thunderbird, Avon, O.K.,* and *Casino.*

Veins in greenstone, mainly andesitic volcanics, are found on the *Prosper, Avon, Noble* and *Noble B.*

Several gold-quartz veins are in areas characterized by an alternation of greenstone and quartz diorite, between which the contrast in physical characteristics is sufficient for breaks to form in the weaker rock of the two—namely, greenstone. The heterogeneity has been achieved by virtue of andesitic dykes in an area of quartz diorite or by granitic dykes in an area largely of greenstone. The vein-fractures tend to follow the contacts, but may cut across the contact and be found in either rock close to the contact. An area in which a heterogeneity of rock-types exists is usually favourable to prospecting.

Veins that follow or cut across the contacts of greenstone dykes in quartz diorite are found on the *Musketeer, Buccaneer,* and *You* properties. Veins in or close to contacts of granitic dykes in greenstone are found on the *Della, Sherwood,* and *P.D.Q.* properties.

A more constant relationship exists between the structural nature of the vein and the nature of the wall-rock than between the strike group and the wall-rock. Simple fissure-veins and sheeted zones are most common in the quartz diorite. Shear-zones are commonest in greenstones, or along contacts of greenstone and granitic rocks, when either rock may be in the dyke form.

Suggestions for Prospecting.—In prospecting in the Bedwell River area it should be borne in mind that the gold-quartz veins are related to the Bedwell River batholith and the Penny Creek intrusive. Whether the relationship is genetic or structural is immaterial, the areal relationship exists.

With reference to the contact of the Bedwell River batholith, the properties found to date are not more than 1½ miles from the contact on the batholith side of the contact nor more than 2½ miles from the contact on the greenstone side. Though such properties as the *Sherwood* and *P.D.Q.* in the greenstone area are from 2 to 2½ miles from the contact of the batholith, they are in an area characterized by numerous granitic dykes and therefore where there is physical contrast in rock-types, a factor that markedly promotes the formation of vein-fractures.

Reasoning from the principles outlined in the section on the features of a favourable prospecting area on pp. 14 and 15 of this publication, and from the distribution of properties in the Bedwell River area, the writer suggests prospecting the contact areas of the Bedwell River batholith for up to 2 miles from the contact on the batholith side and for up to 3 miles from the contact on the greenstone. The same procedure may be followed with respect to the Penny Creek intrusive, but the width of the effective contact area will be narrower because of the smaller size of the intrusive.

Our knowledge of the area is still insufficient to tell why the best properties in the Bedwell River are where they are with respect to the north-westerly trend of the batholith, or whether similar veins occur at other points along the contact-zone. In lieu of such knowledge, one can only prospect the length of the contact-zone, hoping to find rich veins.

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KENNEDY (ELK) RIVER AREA.

Location and Access.—The Kennedy River-Taylor River section lies easterly from Ucluelet on the west coast and westerly from Great Central Lake near Port Alberni.

Kennedy River may be reached by a 30-mile water route from Tofino via Kenn Falls, Kennedy Lake to Kennedy River. Another route is from Tofino or Ucluelet via truck-road and pack-horse trail which follows the south-eastern side of Kennedy Lake and Kennedy River. Taylor River is reached from Port Alberni via motor-road to Sproat Lake, and by boat up the lake to Taylor River. A pack-horse route leads up Taylor River and over a low divide into Kennedy River.

History.—Interest was shown and work done in the area in the late '90's when the *Rose Marie* operated a 4-stamp mill for a couple of seasons; the only properties upon which work has been done recently are the *Leora* and *Tommy K.*

Production.—About nine gold properties and prospects, including the *Blue Bird, Gold Queen, Gold King, Golden Glove, Grant, Jo-Jo, Leora, Rose Marie,* and *Tommy K.*, have been staked and prospected on Kennedy River. These copper properties, including a small gold-copper prospect, are all found north of Kennedy Lake. Three properties, the *Tommy K.* (belonging to Kennedy Lake Gold Mines), *Leora,* and *Rose Marie* properties have produced, and of these the *Leora* was the largest producer. The total production is reported to have amounted to 436 tons containing 312 oz., an average of 0.71 oz. gold per ton.

Geology.—The area has not been mapped geologically and only the geology adjacent to the properties is known. The area is largely underlain by greenstone, with a small granodiorite stock about 5 miles up Kennedy River.

Gold-quartz Veins.—The veins occupy either narrow shear-zones or tight fractures in greenstone, or, in the case of the *Jo-Jo,* are in a small granodiorite stock. The vein-matter, consisting of quartz and sulphides, is narrow, 10 inches being a good average width, although one vein reaches a width of 2 feet. The sulphides include pyrite with small amounts of chalcopyrite, sphalerite, and galena. In some veins pyrite is abundant. One vein, the *Rose Marie,* is strongly ribboned, 1-inch plates of quartz are separated by paper-thin layers of schistose greenstone. The veins range in strike from north-easterly to easterly. Most of the veins, as known at present, are either too narrow or too low in gold to yield mineable ore.

Gold has been found 20 miles west of Port Alberni, 4 miles west of the western end of Sproat Lake, on the property of the Taylor River Gold Mines, where quartz veins up to 3 feet wide have been found in greenstone. Assays up to 1 oz. across 4.6 feet have been reported. There is no record of any shipments.

Suggestions for Prospecting.—The writer makes the customary suggestion to prospect carefully the immediate area of known mineral occurrences and to work out gradually from such areas. To date most of the known properties are found in the lower 5 miles of Kennedy River, with one over in the Taylor River Valley.

The writer would suggest prospecting in the country between the headwaters of the Kennedy and Taylor Rivers. Within the past few years this country has been opened up by a pack-horse trail and it is possible to get through to Taylor River. Based only on the fact that gold prospects have been found both on Kennedy and Taylor Rivers, the suggestion is made that the area between be prospected. The gold veins so far found on either river have not proved to be economic and something considerably better on the surface would have to be found to warrant expenditure of money on transportation facilities and development-work.

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ALBERNI CANAL.

The country adjacent to Alberni Canal is extensively mineralized. The southern section south of the Nahmint River and on both sides of the canal is characterized by a copper mineralization of the contact metamorphic type. About twelve copper properties have been found on the western side of the canal and five on the eastern side, but of these only six have produced. This production has amounted to 4,240 tons, containing 646,229 lb. of copper, or ore of an average grade 7.6 per cent. copper and negligible gold.

Gold mineralization is characteristic of the country east of the northern part of the canal, but except for one copper prospect, the *Dauntless*, no mineral of value has been found on the western side.

East of the canal eight gold properties are found within an area that extends southerly from the Vancouver Island Gold Mines property on China Creek 11 miles to the *W.W.W.* property on Corrigan Creek. As far as known at present this mineralized area extends easterly from these properties for 6 miles to the Nitinat River Valley.

Access.—All the properties in this section are reached from Port Alberni. The properties of the Vancouver Island Gold Mines, Limited, and Havilah Gold Mines, Limited, on Mineral and McQuillan Creeks respectively, are reached by motor-road from Port Alberni up China Creek. The properties up the Franklin River and at the head of the Nitinat River—namely, the *Thistle*, *Black Panther*, and *Black Lion*—are reached from Underwood Cove, 8 miles down the canal from Port Alberni, and thence by 12 miles of auto-road to the *Thistle* and by 3 miles of pack-horse trail to the *Black Panther* and *Black Lion*. The *W.W.W.* on Corrigan Creek is reached by about 10 miles of logging-railroad and trail from Franklin River, which is about 12 miles down the canal from Port Alberni.

History.—The gold-quartz veins in the China Creek area were found subsequent to early placer operations in China Creek. Considerable activity in placer-mining was carried on as early as 1862, principally by the Chinese. The creek was reported to have been staked for hydraulic leases for 12 miles in the '90's. The total placer production is unknown, but is known to be over $40,000.

Prospecting for lode gold was active between 1892 and 1900. By 1895 gold-quartz veins had been found and staked on Mineral Creek, in King Solomon basin at the head of McQuillan Creek, and in the Golden Eagle basin at the head of China Creek. The *W.W.W.* property at the head of Corrigan Creek was staked in 1898. In 1898 an 8-stamp mill was built on Mineral Creek to treat ore from the veins on the Alberni Consolidated property (Vancouver Island Gold Mines, Limited, property), but only two clean-ups were made.

Activity had died down by 1900 and little was done in the area until 1933 when Vancouver Island Gold Mines, Limited, began to explore the veins on the Alberni Consolidated ground on Mineral Creek. This company worked for three years and built a 35-ton pilot-mill in 1936, but difficulties of operation forced it to close the same year and further work on the property ceased. However, in 1936 gold-quartz veins above King Solomon basin were opened up by the Havilah Gold Mines, Limited, and a small quantity of ore was produced between 1936 and 1939. Since 1936 mining activity in the area has been intermittent.

Between 1938 and 1942 a small tonnage of high-grade ore was shipped from the *Thistle* on Franklin River and from the *W.W.W.* on Corrigan Creek.

During 1941 active prospecting was carried on by Pioneer Gold Mines, Limited, and by Bralorne Gold Mines, Limited, on the *Black Panther* and *Black Lion* prospects at the headwaters of the Nitinat River.

Production.—Four properties have produced gold ore amounting to 8,432 tons, containing 3,700 oz. of gold; and some copper; the ore from one of the properties, the *Thistle*, also yielded copper amounting to 626,556 lb. The average grade of the total production is 0.44 oz. gold per ton; this ranged from 0.25 to 4 oz. of gold per ton for the total production of the lowest and highest grade producers.

Geology.—Three large areas of granitic rocks are found in the China Creek area. An area about 1½ miles wide extends south-easterly from Port Alberni for 5 miles across China Creek a short distance. A second area extends southerly from a point 7 miles down the canal and 2 miles east of it for at least 7 miles. This area is 2½ miles wide where it crosses Franklin River but it narrows to one-half mile wide at Corrigan Creek. A third large area or belt of granitic rocks, mainly dioritic in composition, extends 1 mile northerly and 4 miles southerly from Mount McQuillan, which is east of the head of McQuillan Creek. This belt of diorite is only one-half mile wide. The rocks of this mass have been intruded along a well-defined north-south fracture-zone. Much of the rock is a fracture-breccia. Three small stock-like areas of feldspar porphyry, ranging from ¼ to 1 mile in maximum diameter, are strikingly aligned along a course that trends south 15 degrees east, from west of the head of McQuillan Creek to the middle fork of the Nitinat River, a distance of 5 miles. Elsewhere in the area the rocks consist mainly of a variety of greenstones, cut when close to granitic areas by feldspar porphyry dykes.

Gold Veins.—The ore-deposits of the area are found in areas of greenstone, but most of them are close to areas of granitic rocks.

With the exception of the *Thistle*, the deposits are gold-quartz veins that contain variable amounts of pyrite, galena, and sphalerite. Good gold values are found in places, but nothing so spectacular as in the Zeballos camp.

In general the veins follow well-developed shears that range in strike from north-westerly to north-easterly. The veins, where well developed, are tabular and the quartz conspicuously ribboned. The widths commonly range from 2 inches to 2 feet.

The wall-rocks include andesite flow-rocks, tuffs, diorites, and feldspar porphyry. A variety of rock-types characterizes the individual properties. At the property of the Vancouver Island Gold Mines, Limited, the wall-rocks include flows and tuffs; at the property of the Havilah Gold Mines, Limited, flow-rocks cut by feldspar porphyries; and at the *Black Panther* and *Black Lion* properties, andesite and diorite.

The *Thistle* deposit at the head of Franklin Creek consists of chalcopyrite replacement mineralization along a major shear-zone in andesite and altered limestone. The limestone has been largely replaced by such high temperature replacement minerals as garnet and diopside.

The most conspicuous feature of the mineralization in the area is a carbonatized shear-zone that follows south from the headwaters of McQuillan Creek, over the divide and down the Nitinat River. This zone of shearing follows the contact between a north-south elliptically-shaped area of diorite, 5 miles long by one-half mile wide, on the east and andesitic greenstone on the west, and is about 1 mile east of the line of feldspar-porphyry stocks mentioned previously. At several places along its strike this carbonatized shear-zone contains narrow ribbons and lenses of quartz mineralized with a small amount of pyrite and galena, and some gold.

The showings on the *Black Panther* and *Black Lion* are at two places along the carbonatized shear-zone where the mineralization has been strong enough to warrant prospecting.

On the *Black Panther* quartz vein-matter, as discontinuous lenses, 6 to 14 inches wide, is found in a shear-zone ranging from a few inches to 4 feet wide. A considerable amount of underground work was done in 1941 on this property but no ore was shipped. At the *Black Lion* the same shear-zone is found, but the quartz is narrower and less abundant. Some surface work was done on this property in 1941.

Suggestions for Prospecting.—The writer suggests that prospectors direct their attention to the periphery of the area of diorite and allied rocks that extends northerly and southerly from Mount McQuillan. Mineralized quartz veins have been found on both sides of this intrusive mass on the *Havilah, Black Panther,* and *Black Lion* on the west, and on the *Golden Eagle* and *B. and K.* on the east.

The line of feldspar-porphyry stocks lying about 1½ miles west of the diorite at Mount McQuillan trends east of south and in going south approaches the diorite. Three miles south of the Mount McQuillan a feldspar-porphyry stock is less than one-half mile from the diorite. Because of the nearness of the porphyry to the diorite at this south end and because of the marked heterogeneity of the rock-types, diorite, andesite, and feldspar porphyry, in a small area, breaks capable of receiving quartz vein-matter are apt to form. The area south from Mount McQuillan appears therefore attractive for prospecting.

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NANAIMO AREA.

Westerly from Nanaimo gold has been found in quartz veins on the *Georgina* at Nanoose Bay and on the *Vulcan* northerly from Nanaimo Lakes.

On the *Georgina* a quartz vein, 12 to 14 inches wide, containing some chalcopyrite and gold values has been found west of and next to a fault separating greenstone from Cretaceous conglomerate. Values up to 1.5 oz. in gold are reported. On the *Vulcan* property, 3 miles north of the second Nanaimo Lake, a well-defined shear-zone, 1 to 3 feet wide, contains two discontinuous ribbons of quartz from 2 to 6 inches wide. The quartz contains abundant sulphides and gold values up to 3.25 oz. have been reported.

The area between the *Georgina* and *Vulcan* has not been mapped geologically, but it is probably mainly greenstone with small areas of granitic rocks. Because good gold values have been found both at the *Georgina* on the north and the *Vulcan* on the south, it is suggested that the country between might be favourable to prospecting for gold-quartz veins.

PROSPECTING POSSIBILITIES ELSEWHERE ON VANCOUVER ISLAND.

Gold in gravel deposits on Nanaimo and Oyster Rivers on the eastern side of the island may have come from lode deposits in the same localities and, if found, such deposits might be of commercial value.

Veins discovered in 1940 on Mount Washington contain gold rather intimately associated with sulphide mineralization. Moderate gold values have been found in fine-grained sulphide replacement deposits on the Dorion property east of Nahwitti Lake, near the northern end of the island.

These occurrences of placer gold, and rather recently discovered gold-bearing lode deposits in localities which previously had received little attention, suggest the possibility that other localities on the island may also be found to contain gold-bearing deposits.

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